The University of Chicago

THE CONCEPTION OF THE TRUE PATH AND EFFICIENCY IN MAZE LEARNING

A PART OF A DISSERTATION SUBMITTED TO THE FACULTY OF THE DIVISION OF THE BIOLOGICAL SCIENCES IN CANDIDACY FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF PSYCHOLOGY
1939

By
A. Q. SARTAIN

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CHICAGO, ILLINOIS

Reprinted from
Journal of Experimental Psychology
Vol. 26, No. 1, January 1940

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Reprinted from the JOURNAL OF EXPERIMENTAL PSYCHOLOGY,
Vol. 26, No. 1, January, 1940
Printed in U. S. A.

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It is a matter of common observation that if one learns a stylus maze with vision excluded he usually builds up some sort of a conception of the true path of the maze. It might be supposed, furthermore, that one learns in proportion to the clearness and accuracy of this conception. The present study is an attempt to test the validity of that supposition. The study will raise such questions as the accuracy of the conception after learning is complete; how the conception functions in the process of learning; and whether a conception arrived at as a result of map study is as valuable as an equally accurate one arising from actual experience in the maze.

Materials Used.—The stylus maze used in this experiment was similar to one previously used by Carr.[1] A metal stylus was inserted in grooves in a metal plate in such fashion that the stylus would slide freely except when prevented by stops so located that they could not be discovered visually. The base of the maze was made of a sheet of duralium, twelve inches square and one-half inch thick. To this were bolted twenty-five squares of the same metal, each one and seven-eighths inches square on top, with the under side, or side next to the duralium plate, one and three-eighths inches square. This left a notch or groove one-fourth inch high and one-half inch wide, running completely around the bottom side of each square. These metal squares were arranged in rows of five each, with one-fourth inch between them. Details of the construction are shown in Fig. 1 and the general pattern in

* From the Psychological Laboratory of The University of Chicago. The writer wishes to express his indebtedness to Prof. H. A. Carr, under whose direction this research was carried out.

[1] Carr, H., The influence of visual guidance in maze learning, *J. Exper. Psychol.*, 1921, 4, 399–417.

Fig. 2. The stops in the pathway were made by bolts which came up through the metal plate within the grooves mentioned above. They were placed under the edges of the squares of metal so that they could not be seen. The stylus was shaped like an inverted *T*, and would not pass the stops.

One of the most difficult and important problems involved in the study was that of testing the subject's conception of the true path. The method finally adopted was the use of a questionnaire concerning the correct pathway, the questions being so arranged that they could be answered by merely checking in the appropriate column, 'Yes,' 'No,' or 'Don't Know.' The subject was furnished with a map of the maze *with no pathway shown on it*, but with the spaces between the

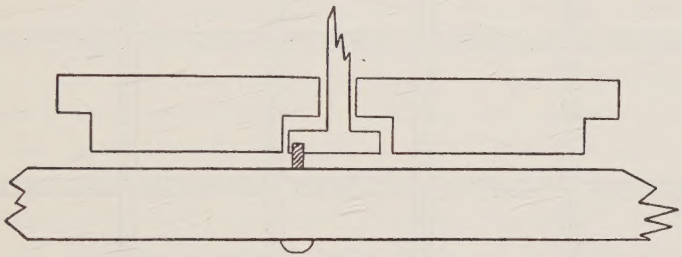

Fig. 1. Cross section through maze, showing base, stylus, metal squares, and stop. (Actual size.)

corners of the metal squares all numbered. These numbers began with '1' in the upper left-hand corner and proceeded from left to right across the map, with a number at each intersection. Thus, across the top there were the numbers from 1 to 6 (with '6' in the upper right-hand corner). Just under the '1' was a '7,' under the '2' an '8,' and so on, until in the lower right-hand corner a '36' was placed. The Questionnaire, based on this map and employing these numbers, was composed of sixty questions concerning the correct pathway. Thirty-six of these were correctly answered by checking 'Yes,' and twenty-four by checking 'No.' Of the false questions several represented merely the wrong direction on the correct pathway. Figure 2 shows the general appearance of the maze, as well as the correct pathway, the blind alleys, and the location of the stops.

In order to determine the sensitiveness of the Questionnaire—that is, its ability to differentiate well between varying degrees of knowledge of the true path—it was administered to twelve subjects before the experiment proper was begun. Accuracy on the Questionnaire, after it had been modified

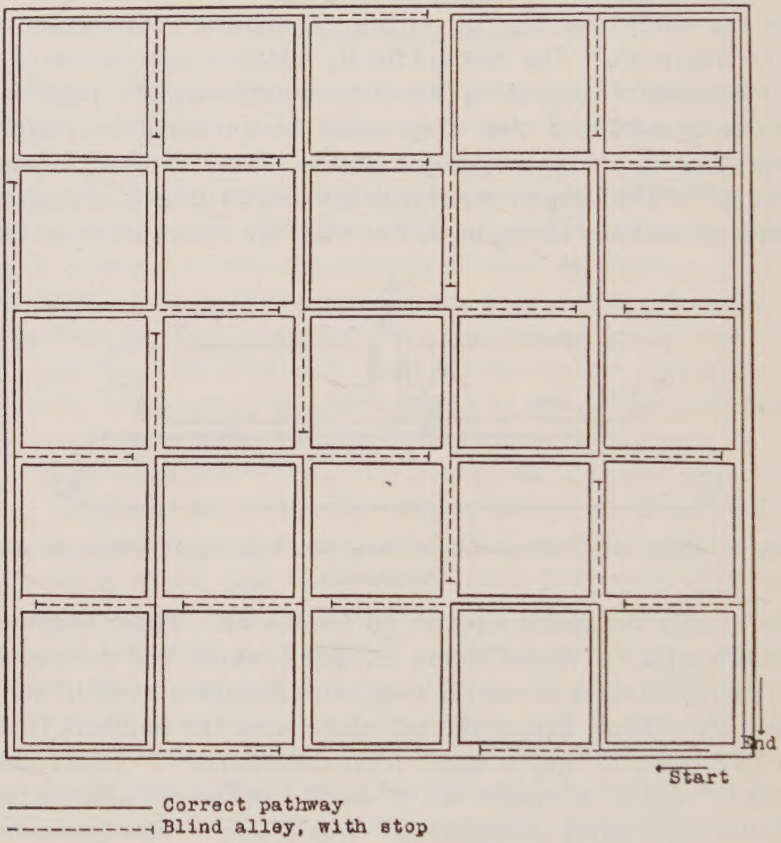

FIG. 2. Map of maze, showing correct pathway, blind alleys, and stops.

somewhat, was found to agree closely with the subject's performance and, in the end, his own estimate of his knowledge. These preliminary trials and subsequent data from the experiment proper seem to justify the conclusion that the Questionnaire served its purpose well. A copy of the Questionnaire is to be found in the Appendix.

Subjects and Conditions of the Experiment.—Six groups of subjects were employed in this study. All of the groups learned the maze with vision excluded by means of a screen. All groups also received typewritten instructions, and were allowed to study the map which showed the general nature of the maze but which had no pathway indicated upon it. They were also allowed thirty seconds of visual inspection of the maze itself. One minute thereafter learning was begun, and it continued until the subject had learned to the extent of three successive errorless trials. An error was considered to be any complete entry into a blind alley or any retracing of the correct pathway by as much as the length of one of the squares.

The maze was learned under three different conditions: first, with no preliminary information concerning the correct pathway but with the Questionnaire to be answered at the end of each third trial during learning (Group I); second, with no preliminary information concerning the correct pathway and the Questionnaire to be filled out only at the end of the learning period (Group II); and third, with varying amounts of preliminary study of a map showing the correct pathway (Fig. 2), the Questionnaire being filled out (1) after the map study and before attempting the maze and (2) after the learning was completed. In this third condition one group studied the map showing the correct pathway for fifteen seconds (Group IIIa); another studied it for thirty seconds (Group IIIb); a third, for sixty seconds (Group IIIc); and a fourth, for one hundred twenty seconds (Group IIId). Thus, for all four of these last named groups there were obtained, by means of the Questionnaire, an Initial Accuracy score (from study of the map showing the correct pathway but without any trials in the maze) and a Final Accuracy score (at the end of learning). As already implied, Group I yields a series of Intermediate Accuracy scores (after each third trial) and a Final Accuracy score. The second group has only the Final score. For all six groups records were kept of time for learning, errors made, and trials to learn. Fifty college students, mostly sophomores, comprised Group I. There were thirty comparable subjects in each of the other five groups.

History of the Problem.—There seem to be no previous studies of the exact questions involved in this experiment. Indeed the number of relevant studies is quite small. The question of the type of imagery used in maze learning and how that imagery functions in the learning process was dealt with by Perrin,[2] who reports that he was 'unable to make any correlation between the type or combination of image processes used with efficiency in maze learning.' Furthermore, scores on tests of memory showed no relationship to efficiency in learning. Illusions as to the correct pathway were general, but as a rule they did not seem to produce bad results. On the whole there was slight correlation between efficiency in learning and 'pure trial and error,' 'pure reasoning,' 'ideational learning,' memory, or imagery.

On the other hand, Warden [3] found evidence that there are three methods of learning a stylus maze, word reaction, visual imagery, and kinesthesis. He found that those who used the first method were greatly superior to those employing the third, with those using the second method intermediate in efficiency.

Lambert and Ewert [4] confirmed the findings of Warden. In addition, they discovered that the more complete the instructions, the less of the motor and the more of the verbal methods were used. Better reproduction of pattern was also displayed by the verbal group.

Husband [5] also obtained results agreeing with those of Warden. He found that the verbalizers were much more slow and deliberate than those using the motor method, but that in the end the former showed a superiority in total time to learn, a superiority that increased with the difficulty of the task.

[2] Perrin, F. A. C., An experimental and introspective study of the human learning process in the maze, *Psychol. Monog.*, 1914, No. 70, 1–97.

[3] Warden, C. J., The relative economy of various modes of attack in the mastery of a stylus maze, *J. exper. Psychol.*, 1924, 7, 243–275.

[4] Lambert, J. F., and P. H. Ewert, Part I: The effect of verbal instructions upon stylus maze learning, *J. gen. Psychol.*, 1932, 6, 377–399.

[5] Husband, R. W., Analysis of methods in human learning, *J. genet. Psychol.*, 1931, 39, 257–278.

Scott [6] also came to the conclusion that verbal imagery was most efficient in maze learning and that there was a 'pronounced tendency to change from motor to verbal learning' during the learning process. He also secured evidence that the maze pattern is retained in memory and at times 'does function in the relearning of the same maze or a similar maze,' though often 'nonconsciously.'

On the other hand, Sackett,[7] attempting to discover the relationship between the retention of a maze habit and the amount of symbolic rehearsal, found a large majority of his subjects used the visual method, with the verbal method next, and finally the motor method. Though only eleven percent of the subjects used one method exclusively in learning, forty-one percent did so in rehearsal and even more in relearning. The visual method, however, predominated in all cases.

Finally, Scott [8] attempted to reconcile the discrepancies in the studies of Perrin, Warden, Sackett, and the others on the assumption that the sort of image secured in maze learning depends upon the type of maze pattern employed. He held that a systematic maze [9] 'is found to call forth in the majority of cases a certain type of imagery peculiar to it,' while an unsystematic [10] one produces variation from subject to subject and within the same subject.

Thus we see that it is generally agreed that, in the process of learning a stylus maze, at least a majority of subjects build up some sort of a conception of the maze pattern. At times this conception may be visual, at other times it may be verbal. In still other cases the learning may be a motor accomplishment. In the present study, therefore, we are making no

[6] Scott, T. C., The retention and recognition of patterns in maze learning, *J. exper. Psychol.*, 1930, 13, 164–207.

[7] Sackett, R. S., The relationship between amount of symbolic rehearsal and retention of a maze habit, *J. gen. Psychol.*, 1935, 13, 113–130.

[8] Scott, T. C., Imagery—to what extent is it a function of the maze pattern? *J. genet. Psychol.*, 1936, 49, 271–278.

[9] By a systematic maze Scott means one composed of a number of similar parts or of units—to use his own words, 'reducible to some common unit,' 'reducible to a unit of construction.'

[10] *Ibid.*

assumptions as to the experiential nature of the conception possessed by the subject, for we are concerned only with its accuracy as related to efficiency of learning.

Another problem involved in this experiment is the effect of visual guidance on maze learning. In this connection Carr,[11] using an experimental set-up similar to the one employed for Group III of this study except that no questionnaire was used, found that visual guidance was effective, especially in the prevention of errors, although the effectiveness was not proportional to the amount of guidance. He also found that, after a certain point was reached, further visual guidance was not effective, since after a time all that may be learned visually has been learned. Furthermore, some subjects who learned with vision excluded made errors when required, after learning, to trace the pathway with vision.

Carr used, for visual guidance, maps revealing varying amounts of information about the correct pathway. He found that "the effectiveness of the guidance upon trials and errors was proportional to the knowledge obtained from the diagram." Looking at the maze was more effective than merely looking at a map of the maze, when no pathway was shown on the map.

When the subjects were required during learning to identify the correct pathway on a map they made many errors at first. Even after the pathway had been correctly identified (after an average of 3.8 trials and 24.2 errors), to traverse the pathway correctly required considerable additional effort (8.0 additional trials, 1.7 additional errors). Conspicuous differences between subjects were noted in this regard, as in other phases of the experiment. Among the author's conclusions one finds this statement:

> Our results at least indicate the probability that the visual modes of control are much more effective in the acquisition and performance of acts of skill than hitherto suspected.[12]

Carr and Osbourn[13] in a similar experiment arrived at

[11] Carr, *op. cit.*

[12] *Ibid.*, p. 417.

[13] Carr, H. A., and E. B. Osbourn, Influences of vision in acquiring skill, *J. exper. Psychol.*, 1922, 5, 301–311.

substantially the same conclusions. They too found that while visual study of a maze is effective in learning a maze, it is not effective in exact proportion to its amount; and further, that "the mastery of the maze in visual terms does not necessarily enable the subject to traverse it successfully with vision excluded." Likewise they found that for a majority of their subjects the introduction of vision disturbed the maze performance if learning up to that point had been carried on with vision excluded. Again, however, the fact of individual differences is emphasized.

Results of the Experiment.—The findings of the present study may be presented under three main headings: first, the relation of Final Accuracy on the Questionnaire to errors, time, and trials for learning; second, the relation of Intermediate Accuracy on the Questionnaire to errors and time up to the particular trial; and third, the relation of Initial Accuracy on the Questionnaire to errors, time, and trials for learning. The first of these relationships will show whether faster learners tend to build up a more accurate knowledge of the pathway. The second will deal with the growth in the accuracy of the conception and with the relationship of the increase in accuracy to learning at various points in the process. The third will show the effect upon subsequent efficiency of the conception obtaining in the beginning of actual maze learning.

One noteworthy fact concerning Final Accuracy is the high score made when the Questionnaire is filled out after learning. Data on this point are given in part in Table 4. Of fifty-nine possible correct answers, for example, Group I had a mean score of 56.28 correct responses (with a probable error of the mean of only .34); Group II had a mean of 53.33 correct responses (probable error, .75); Group IIIa, 56.73 correct answers (probable error, .31); Group IIIb, 56.73 correct answers (probable error, .26); Group IIIc, 57.43 correct answers (probable error, .39); and Group IIId, 57.00 correct responses (probable error, .27).

Thus it may be seen that, as a general rule, subjects tend to have an accurate conception of the true path by the time they reach the standard required for the last three trials,

although a perfect conception is obviously not necessary for the requisite final performance. The small probable errors indicate a strong tendency for the scores to bunch at the upper end of the distribution, a fact which will be referred to later in another connection.

The relationship of Final Accuracy on the Questionnaire to total time, errors, and trials is shown in Table 1. Generally

TABLE 1

Relation of Final Accuracy on Questionnaire to Rate of Learning

Group	Coefficient of Correlation between		
	Accuracy and Total Time	Accuracy and Total Errors	Accuracy and Trials
I	−.1606	−.3069	−.5601
II	−.5016	−.4461	−.3934
III Total	−.2771	−.2021	−.2417
IIIa	+.0406	+.0757	+.0187
IIIb	−.4901	−.3774	−.4426
IIIc	−.3373	−.2653	−.1530
IIId	−.3504	−.3026	−.3197

speaking, the correlations are quite low, although in each case except for Group IIIa the correlations are all negative, that is, a higher score on the Questionnaire tends to go with lower error, time, and trial scores. In other words, the more accurate the conception, the faster is the rate of learning. For Group II all coefficients are −.39 or above, but the average coefficient for all groups is only −.28. Thus it may be seen that while there is an inverse relationship between Final Accuracy and time, trials, and errors, the relationship is relatively low for all groups. With one exception correlations are higher for Group II than for Groups I and III but not markedly so.

The small size of the average correlation in this connection is somewhat surprising. In part the lowness of the figures doubtless is due to the distribution of the Final Accuracy scores. As has already been stated, there is a tendency for those scores to gravitate towards the upper part of the distribution, with the consequent effect, of course, of lowering the coefficient of correlation. It seems quite likely, moreover,

that the greater distribution of scores for Group II helps to explain its somewhat higher coefficients of correlation. However, in spite of these facts the conclusion seems quite clear: the relationship between the conception held by an individual and his rate of learning, while definitely present, is low. It is worth noting that for the fifteen second group (Group IIIa), as has already been pointed out, the correlation is non-existent. Perhaps fifteen seconds is too short a time to influence the final conception, but, as will be seen later, it has a definite effect on efficiency in learning.

It should also be noted that the Final Accuracy scores for Groups I, IIIa, IIIb, IIIc, and IIId are decidedly higher than those for Group II. It will be recalled that Group I filled out the Questionnaire after each third trial and that Groups IIIa, IIIb, IIIc, and IIId all studied maps of the maze. Evidently these activities tend to improve Final Accuracy.

The second problem raised by the study concerns the development of the conception and its relation to learning. As one would expect, there are here as elsewhere great individual differences. A few of the subjects are never able to fill out the Questionnaire with any accuracy, even at the conclusion of the experiment, nor do they show evidence of any clear conception of the true path at any time during learning. Other subjects, on the contrary, seem to have the conception before they can follow the path in the maze. Most subjects, of course, lie between these extremes.

That the conception grows very much from the beginning to the end of the experiment is at once evident when the individual records are inspected, but the data are rather difficult to present in tabular form because of the fact that as soon as a subject completed three successive errorless trials he dropped out of the group. One subject, for example, finished with the sixth trial, another with the ninth, two more with the tenth, etc. Thus, the average Final Accuracy scores after each third trial would be based on fewer and fewer subjects, and these subjects are the slowest learners. However, the average Accuracy score of all subjects after the third trial in the maze was 34.2 correct answers, or nearly sixty percent of a perfect

score. And since the average Final Accuracy score for Group I was approximately 56.3, as already pointed out, this indicates an average gain of 22.1 correct answers during the course of the experiment. Furthermore, the highest scores were made at or near the end of the learning period. Thus, for 19 of the 50 subjects the highest accuracy attained during the experiment was just after the completion of learning, and 43 of the 50 made their highest score within three trials of the last.

The conclusion from this section of the study, therefore, substantiates one previously drawn: increasing ability to execute a successful maze performance is accompanied to some extent by an increasing accuracy of the conception of the true path of the maze.

Correlations between Intermediate Accuracy scores and learning and between Intermediate Accuracy scores and performance are shown in Tables 2 and 3. Table 2 shows the correlations between Intermediate Accuracy (that is, accuracy at the end of the third trial, sixth trial, ninth trial, etc.) and time consumed and errors made to that point in the learning process. As previously noted, because of the dropping out of subjects after three successive errorless trials, the correlations are based on fewer and fewer subjects as one reads down the table. Correlations obtained in this way are considerably higher than those of Table 1, if the smaller groups are disregarded. Indeed the average coefficient through the fif-

TABLE 2

Relation between Accuracy on Questionnaire and Learning to that Point

Trial	Coefficient of Correlation between Correct Answers and		Number of Subjects
	Total Time (to that Point)	Total Errors (to that Point)	
3	−.4780	−.2940	50
6	−.4100	−.6010	50
9	−.5773	−.6440	49
12	−.4381	−.6414	45
15	−.3730	−.6959	39
18	−.1462	−.4424	31
21	+.1773	−.0196	22
24	+.3025	+.1300	18
27	−.3285	+.0440	11
30	+.3874	+.1657	8

TABLE 3

RELATION BETWEEN ACCURACY ON QUESTIONNAIRE AND PERFORMANCE ON NEXT TRIAL

Trial	Coefficient of Correlation between Correct Answers and		Number of Subjects
	Total Time (on Next Trial)	Total Errors (on Next Trial)	
3	−.2763	−.2830	50
6	−.3314	−.4151	49
9	−.3612	−.4880	48
12	−.2089	−.5874	43
15	−.0717	−.4517	37
18	−.4089	−.3677	27
21	−.3933	−.5370	21
24	−.4934	−.5581	14
27	−.2511	−.3573	9
30	−.0828	+.0229	7

teenth trial in Table 2 is −.52. This may mean that the better learners develop more accurate conceptions and drop out earlier while the poor learners reduce the ultimate correlation, or it may be due to the fact that the range of the accuracy scores is greater. At any rate the developing conception correlates more highly with learning scores to that point than the final conception does with final learning scores. It is possible, therefore, that while the development of a conception of the pathway of the maze is by no means the only factor in learning, it is a factor of some importance.

Another aspect of the experiment, previously considered in part, is the effect on Final Accuracy, time, errors, and trials of filling out the Questionnaire at the end of each third trial. The answer to this question may be found by comparing the scores for Groups I and II, as these appear in Table 4. For all four criteria the advantage is with those who answered the Questionnaire after each third trial. Thus, these subjects finally answered, on the average, 56.28 questions correctly, while those who answered the Questionnaire only at the end of the experiment replied correctly on the average to only 53.33 questions. Group I likewise made only 508.08 errors per subject, while Group II made 617.23 errors. Group I required only 20.86 trials for learning, Group II, 27.70 trials. Group I consumed on the average 2312.02 seconds in learning,

while Group II required 2547.70 seconds. The superiority of Group I may be explained in part on the basis of motivation, for the more quickly the subjects could finish, the fewer times the rather long Questionnaire had to be filled out. But this seems hardly sufficient to explain differences so large. The subjects frequently reported that an opportunity to 'collect their thoughts' about the correct pathway was definitely helpful, and certainly the evidence cited above seems to bear them out.

When one observes the correlations between Intermediate Accuracy on successive third trials and time and error scores on the next succeeding trials (Table 3), he is struck by the fact that they are usually lower than the ones just dealt with. Doubtless the chance factors influencing the scores for a single trial in the maze are relevant here. Why these correlations should reverse the trend and actually be higher during the last few trials is not clear.

A noteworthy feature in this connection is the effect of filling out the Questionnaire on scores on the next succeeding trial. Here, on the average, time and error scores practically always rose over the trial preceding, that is, more time was required and more errors made on the fourth trial than on the third, on the seventh than on the sixth, etc. It is suggested by way of explanation that erroneous conceptions were worked out in answering the Questionnaire and that these conceptions induced errors when tried out. However, experience with the maze and the blank map frequently gave the subject a better conception of the correct pathway when he had discovered his errors. This conclusion is in keeping with statements frequently made by subjects on the first and second trials following the Questionnaire.

Thus far we have seen that the conception held by the subject correlates, sometimes fairly well and at other times less well, with his rate of learning in the maze. It has not been possible to show a causal relationship, however, for it is entirely possible that the conception merely accompanies the learning, without exerting any influence upon it. It now remains to consider the effects on learning of a conception

induced before experience with the maze itself (Groups IIIa, IIIb, IIIc, and IIId).

That map study definitely induces a conception of the pathway is apparent from Table 4. Fifteen seconds of study, for example, enabled the average subject to answer more than two-thirds of the questions correctly, and one hundred twenty seconds raised this to almost nine-tenths. And though the relationship between time and Initial Accuracy is by no means one-to-one, the group studying the map for thirty seconds stands next to first, and the one studying for sixty seconds has the next to the best score in Initial Accuracy.

TABLE 4
EFFECT OF MAP STUDY

Group	Duration of Map Study	Initial Accuracy on Questionnaire	Final Accuracy on Questionnaire	Trials	Errors	Time
I	—	—	56.28	20.86	508.08	2313.02
II	—	—	53.33	27.70	617.23	2547.70
III Total		47.05	56.97	13.03	148.16	1041.43
IIIa	15 sec.	40.96	56.73	16.93	209.53	1341.31
IIIb	30 sec.	43.06	56.73	16.00	249.46	1471.40
IIIc	60 sec.	51.50	57.43	10.40	87.73	840.75
IIId	120 sec.	52.67	57.00	8.80	45.93	539.26

One of the problems in this connection is the effect of such a conception on trials, errors, and time for learning. Table 4 brings out the essential relevant facts. In all three cases the groups studying the map were definitely superior, the superiority increasing with increasing amounts of map study. It is true that differences between Groups IIIa and IIIb are slight, and in the case of errors and time actually favor the group studying for the shorter period. But such is certainly not the case for Groups IIIc and IIId. In these cases the superiority of longer map study is clearly evident.

Group IIId is likewise superior to Group IIIc. Although differences in Initial Accuracy are small, for errors and time especially Group IIId is far ahead.

It is interesting to note that with all the success of groups spending more time in map study, the superiority, with the possible exception of errors, is not proportional to the amount

of time spent in learning. Indeed, eight times as much time in study (Groups IIIa and IIId) lessened trials by only one-half and time by less than two-thirds. Errors, however, are diminished by almost five-sixths. Similar results are obtained by comparisons of other groups. Errors, therefore, seem to be affected most.

Inspection of Table 4 leads one to conclude that for this particular problem, when time intervals are short, additional time makes little difference (Groups IIIa and IIIb). This conclusion, however, does not obtain for the longer intervals. Had still longer periods been used additional time might have had less effect.

Another approach to the problem of the relation of the initial conception to time, errors, and trials for learning is to correlate Initial Accuracy scores with these learning criteria. Here, as Table 5 reveals, the correlation is fairly high, the

TABLE 5

Relation of Initial Accuracy on Questionnaire to Learning

Group	Duration of Map Study	Coefficient of Correlation between Correct Answers and		
		Total Time to Learn	Total Errors to Learn	Trials to Learn
IIIa	15 sec.	−.6584	−.4731	−.3839
IIIb	30 sec.	−.3533	−.2005	−.4540
IIIc	60 sec.	−.6960	−.7059	−.6958
IIId	120 sec.	−.6349	−.7100	−.5837
III Total		−.6351	−.4975	−.6354

coefficients rather considerably exceeding those obtained elsewhere in the experiment. Only one coefficient is below −.35, and the average is −.55. The size of these correlations may best be appreciated when they are compared with those of Table 1, dealing with Final Accuracy as it relates to these measures. With a single exception the former are higher and in most cases markedly so.

Thus, because the more accurate the initial conception, the lower the time, errors, and trials required for learning and because Initial Accuracy correlates definitely with the learning criteria, we arrive at the conclusion that the conception held at the beginning of maze learning may definitely influence the rate of learning. And certainly if this statement holds for

Groups IIIa, IIIb, IIIc, and IIId, it may safely be said to obtain for Groups I and II also. It will be remembered that for the latter groups the only data available showed a correlation of conception and rate of learning, but no method of showing actual influence was available. Data just presented for Groups IIIa, IIIb, IIIc, and IIId remedy that defect.

Data are also available on another problem having to do with the effect of the conception on learning: is a certain accuracy of conception gained through map study as effective as an equally accurate conception built up in actual experience in learning the maze path? To answer this question Groups IIIa, IIIb, IIIc, and IIId were compared with subjects taken from Group I, those subjects being selected in each case whose average Intermediate Accuracy was practically the same as the Initial Accuracy of the particular group concerned. To illustrate: the Initial Accuracy of Group IIIa was 40.96 correct answers. When all subjects from Group I who at the end of any third trial had an Intermediate Accuracy score of 40, 41, or 42 were considered as a sub-group (S–Ia), it was found that their average accuracy score was 41.00. The question was then to determine whether Group IIIa learned the maze with less errors, time, and trials than did this sub-group, assuming that the next trial after the 40, 41, or 42 score was the *first trial* for the subjects in the sub-group. The sub-group to be compared with Group IIIb (Initial Accuracy 43.06) was composed of those subjects making at some time Intermediate Accuracy scores of 42, 43, or 44 (S–Ib). Group IIIc (Initial Accuracy 51.50) was compared with those scoring 51 and 52 (S–Ic), and Group IIId (Initial Accuracy 52.67), with those scoring 52 and 53 (S–Id). The results obtained are shown in Table 6.

As far as the learning criteria are concerned, the results show clear superiority for the sub-groups in every comparison. Thus, Group IIIa required 16.93 trials to learn, while Group S–Ia required only 14.09 trials. Group IIIa required 209.53 errors as against 82.14 errors for Group S–Ia, and 1341.31 seconds as against 700.61 seconds. Similar comparisons could be made for the other groups, with the greatest differences in errors in all cases and the least in trials. It is

TABLE 6

EFFECTIVENESS OF CONCEPTION GAINED THROUGH MAP STUDY AS COMPARED TO THAT GAINED THROUGH EXPERIENCE IN MAZE

Group	Number of Subjects	Initial Accuracy on Questionnaire	Final Accuracy on Questionnaire	Trials	Errors	Time
IIIa	30	40.96	56.73	16.93	209.53	1341.31
S-Ia	22	41.00	55.23	14.09	82.14	700.61
IIIb	30	43.06	56.73	16.00	249.46	1471.40
S-Ib	23	43.13	55.44	11.78	50.70	567.53
IIIc	30	51.50	57.43	10.40	87.73	840.75
S-Ic	18	51.28	55.78	7.39	12.83	299.70
IIId	30	52.67	57.00	8.80	45.93	539.26
S-Id	23	52.57	56.70	5.70	5.52	229.29

clear, therefore, that the initial trials of the sub-groups influenced learning in other ways than simply in building up the conception.

To guard against the possibility that the better record of the sub-groups might be attributed to the possession of greater learning ability, the average trial, time, error, and Final Accuracy scores of each sub-group *for the entire period of its learning* were compared with those of Group I as a whole. It was found that three of the four sub-groups were actually below the average in learning ability, and the fourth but slightly above. The results noted, then, could hardly be attributed to greater ability.

The Final Accuracy scores of Groups IIIa, IIIb, IIIc, and IIId deserve some attention. In the first place, these groups definitely excelled the corresponding sub-groups in Final Accuracy (Table 5), although for the group studying the map the longest time (IIId) the difference is slight. That a difference of this sort should occur, however, is quite logical when one considers that Groups IIIa, IIIb, IIIc, and IIId had studied a map on which the pathway was clearly traced out, while Groups S-Ia, S-Ib, S-Ic, and S-Id had acquired their information from the maze itself. Thus, each set of subjects seems to have learned best what it practiced most, the map-study groups to recognize the pathway in terms of a map and the sub-groups to traverse more efficiently the true pathway.

In the second place, there is but little difference in Final Accuracy between Groups IIIa, IIIb, IIIc, and IIId (Table 4). Groups IIIa and IIIb were lowest with exactly the same score, Group IIId was next, and Group IIIc highest. As is evident, however, from a consideration of the means and probable errors, none of the differences are statistically significant.

In the third place, when Groups IIIa, IIIb, IIIc, and IIId are compared with Group I, differences in Final Accuracy are again insignificant. But assuming that a difference between the means is significant when it is four times the probable error of the difference, we find that Groups IIIa, IIIb, IIIc, and IIId are superior to Group II. This, of course, would be expected in view of the fact that Group II had only one contact with the map, and therefore devoted practically its entire energy to learning to traverse the maze and not to answering the Questionnaire.

Parenthetically, the difference between the means of Groups I and II is 3.7 times the probable error of the difference. Since Group I also had several contacts with the Questionnaire, the near-significance of this difference supports the conclusion just drawn.

Finally, from a comparison of the coefficients of correlation of time, errors, and trials with Final and Initial Accuracy it is at once apparent that Initial Accuracy correlates more highly than does Final Accuracy. As previously noted, the greater bunching of the latter scores towards the upper end of the distribution likely helps explain this difference. It is entirely possible, however, that the relationship between performance and accuracy is higher at an earlier stage in the learning process than it is at the end. Indeed the data of Table 2 lend some support to this possibility.

Summary and Conclusions.—Two hundred college students, divided into six groups, one of fifty subjects and the other five of thirty each, learned a visual type of maze with vision excluded. From time to time in the experiment and for all subjects at the end of the experiment the accuracy of the conception of the true path of the maze was tested by means of a questionnaire designed for the purpose. The group

of fifty subjects filled out the Questionnaire at the end of each third trial in the maze, and four of the other five groups filled it out after varying amounts of study of a map of the maze and after learning. One group filled out the Questionnaire at the end of the learning period only.

Several conclusions may be drawn from the data presented. First, each individual does develop a conception of a stylus-maze pattern as he learns the maze. In some individuals this conception seems to be quite faulty and in others perfect or well-nigh so. As was pointed out, however, the conception finally attained a high degree of accuracy on the average.

Second, this conception is extremely inaccurate in the early stages of learning, but it increases in accuracy as learning progresses.

Third, the relationship of the accuracy of the developed conception to efficiency in learning is relatively small. This is true whether one judges by final accuracy or intermediate accuracy but particularly so in the former case. It seems, therefore, that learning a stylus maze is something other than merely building up a conception of the pattern.

Fourth, a conception developed in the maze itself, as a result of running the maze, is much more effective than one developed from map study.

Fifth, the accuracy of the conception gained through map study correlates more closely with the learning criteria than does the final accuracy of the conception. This may be due to an artifact of the data, the distribution of scores in final accuracy being quite restricted, or to the possibility that the conception functions more effectively in the earlier than in the later stages of learning.

Sixth, pauses for working out one's conception on a blank map are of considerable benefit ultimately, even though the pauses prove to be distractive on the next trial.

Finally, to induce the conception artificially by means of map study is definitely of value, although, as already pointed out, knowledge gained from the maze itself is more efficacious. In general the amount gained by map study increases with the amount of study, although there is no reliable difference for the shortest intervals.

This study might be viewed as forging one more link in the chain which restrains and makes untenable that intellectualistic view of psychological functioning which holds that maze learning is proportional to knowing and hardly to anything else. Learning is clearly related to knowing, but the relationship is far from directly proportional.

(Manuscript received May 29, 1939)

APPENDIX

Directions.—By referring to the map before you, answer the questions below, checking in the column opposite the question, 'Yes,' 'No,' or 'Don't Know.' Please note the direction implied in the question; for instance, to say *from 36 to 35* is not the same as to say *from 35 to 36.* The first question is correctly checked as an example.

QUESTIONNAIRE FOR DETERMINING ACCURACY OF THE CONCEPTION OF THE MAZE PATTERN

Should One Go from	Yes	No	Don't Know	Should One Go from	Yes	No	Don't Know
36 to 35?	X			1 to 2?			
28 to 29				19 to 13			
21 to 20				3 to 4			
35 to 34				16 to 15			
32 to 31				8 to 9			
28 to 27				7 to 1			
29 to 28				9 to 15			
20 to 26				16 to 10			
33 to 27				13 to 14			
26 to 20				3 to 9			
31 to 32				23 to 22			
28 to 34				6 to 12			
25 to 19				11 to 17			
27 to 21				4 to 10			
25 to 26				12 to 18			
35 to 29				16 to 22			
22 to 21				4 to 5			
34 to 33				22 to 23			
26 to 32				17 to 11			
31 to 25				5 to 4			
14 to 8				18 to 24			
13 to 19				10 to 4			
14 to 15				11 to 12			
9 to 10				23 to 17			
2 to 3				24 to 18			
7 to 8				5 to 6			
15 to 21				18 to 17			
9 to 3				24 to 30			
8 to 7				11 to 10			
15 to 16				30 to 36			